INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: 21.4.2011 AN | Time: 3 Hrs. | Full Marks: 50 | No. of students: 205
Spring Semester 2010-2011 | Dept. of E&ECE | Sub. No. : EC 21008 / EC 21010
2nd Yr. B.Tech.(H) | Sub. Name: ANALOG ELECTRONIC CIRCUITS

Instruction: ANSWER **ALL** THE **FIVE** QUESTIONS
ANSWER TO ALL THE PARTS OF A QUESTION SHOULD BE TOGETHER.

1. (a) Draw a two stage amplifier consisting of a common source (CS) amplifier followed by a common collector (CC) stage. With the following device parameters and operating point information, calculate the small signal voltage gain and the output resistance of the cascaded amplifier.
$V_{DD} = V_{CC} = 10$ V, $I_{DQ} = 1$ mA, $V_{DSQ} = 6$ V, $I_{CQ} = 5$ mA, $V_{CEQ} = 4.7$ V,
$K = 0.5$ mA/V^2, $V_{th} = 2$ V, $\lambda = 0$, $V_{BE(ON)} = 0.7$ V, $V_T = 25$ mV, $V_A \rightarrow \infty$, $\beta = 100$. [4]

(b) Draw the schematic diagram of a Class AB output stage. Briefly explain its principle of operation and power savings with the help of its voltage transfer characteristics. [4]

(c) For a Class AB amplifier, if the power supply rail is ± 10 V:
(i) Calculate the maximum possible output power when the load resistance is 8 Ω (whose other end is connected to ground).
(ii) Calculate the maximum power efficiency of the output stage for an applied input signal of $5\text{V}\cdot\sin(2000\pi t)$. [4]

2. (a) Suppose the amplifier whose circuit is shown in the accompanying figure is called Amplifier A. Another amplifier can be obtained by bypassing the emitter resistor of Amplifier A with a capacitor of very high capacitance, and the new amplifier circuit is called Amplifier B. Calculate the voltage gain and the input resistance of (i) Amplifier A and (ii) Amplifier B, under unloaded condition. Assume $V_{BE\,(ON)} = 0.7$ V, $V_T = 25$ mV, $V_A \rightarrow \infty$, $\beta = 100$. [4]

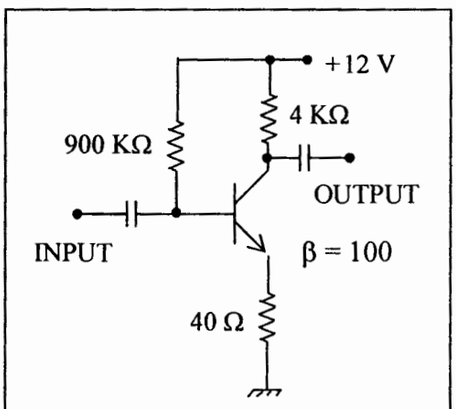

Figure pertaining to Question 2.

(b) Calculate the voltage gain and the input resistance of the overall two stage cascaded amplifier with the final output unloaded, where
(i) Amplifier A is followed by Amplifier B and
(ii) Amplifier B is followed by Amplifier A. [4]

(c) Starting with the cascaded amplifier mentioned in part (b) (i) of this question, connect a single resistor (say, R_F) between the appropriate nodes in the circuit to establish a global voltage-series feedback. Find out the value of R_F, such that the voltage gain of the unloaded two stage feedback amplifier becomes 800. [4]

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3. (a) Draw the circuit diagram of a differential amplifier using only MOSFETs. The amplifier must have active load with differential (double ended) output. The current source should be implemented with MOSFET based simple current mirror. Draw the circuit diagram of another MOSFET based differential amplifier similar to the previous one, where the output is converted to a single ended one. [4]

(b) Draw proper equivalent circuit depicting differential mode of operation for the *double ended* differential amplifier mentioned in part (a) of this question, and derive the expression for its differential gain. [4]

(c) Draw proper equivalent circuit for common mode operation of the *single ended* differential amplifier and derive the expression for its common mode gain. [4]

4. (a) Draw the schematic diagram of an inverting amplifier using an op-amp, a 4 KΩ resistor and a feedback resistor R_F. With the inverting amplifier, cascade a two stage high pass C-R circuit, consisting of two 4 KΩ resistors and two 2 nF capacitors. Assuming the op-amp to be an ideal one, calculate the values of the poles of the transfer function of the cascaded circuit. [4]

(b) Draw the Bode plot (for magnitude and phase) of the cascaded circuit mentioned in part (a) of this question, clearly indicating the important frequencies. Draw the Nyquist diagram for the same cascaded circuit and indicate the phase margin when the circuit is intended to be used in a feedback configuration. [4]

(c) Connect an additional 2 nF capacitor to the cascaded circuit obtained in part (a) of this question, to make a sinusoidal oscillator. With justification, calculate the value of R_F required to get sinusoidal oscillation. Calculate the frequency of oscillation. [4]

5. In which region of operation, a p-MOSFET is biased, when it is used as an active device in an amplifier? State the voltage conditions to keep the MOSFET in that region of operation. [2]

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